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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : G01M 1/22, G06F 15/20 — A1

(11) International Publication Number: WO 90/03561

(43) International Publication Date: 5 April 1990 (05.04.90)

(21) International Application Number: PCT/US89/04177

(22) International Filing Date: 28 September 1989 (28.09.89)

(30) Priority data:

250,360	28 September 1988 (28.09.88)	US
354,267	19 May 1989 (19.05.89)	US
Not furnished	22 September 1989 (22.09.89)	US

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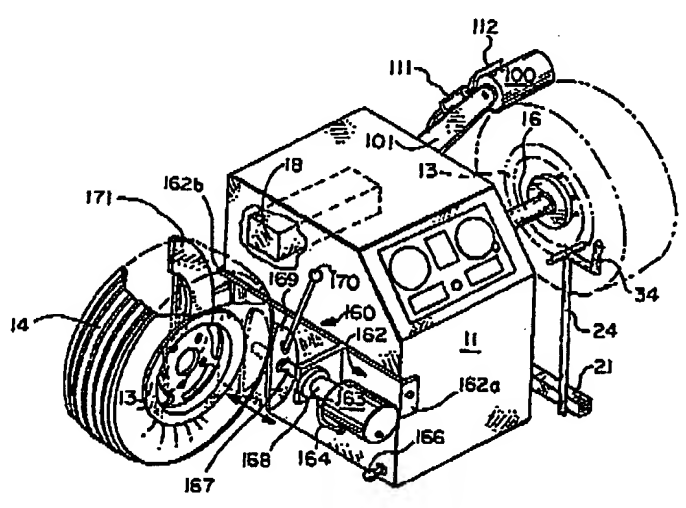
(81) Designated States: DE (European patent), IT (European patent), JP.

Published
With international search report.

(54) Title: SIMPLIFIED DATA INPUT SYSTEM FOR DYNAMIC BALANCING MACHINE AND WHEEL DIAGNOSTIC SYSTEM



(57) Abstract

A dynamic wheel balancing machine includes a rigid frame (11) and means (16) for supporting and rotating a vehicle wheel/tire assembly (14). The balancing machine further includes means (104) for detecting force variation in the wheel/tire assembly as well as means (100, 101) for detecting out of round portions of the rim and means (18) designating where the tire should be rotationally located with respect to the out of round portions of the rim to establish optimum "roundness" to the wheel/tire assembly. The rigid frame carries a bead breaker assembly (160) for use in raising the tire from its associated rim. The bead breaker assembly serves to readily permit the tire to be repositioned by rotating same on the rim to the portion designated as the preferred position to establish the optimum roundness.

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SIMPLIFIED DATA INPUT SYSTEM FOR DYNAMIC BALANCING MACHINE AND WHEEL DIAGNOSTIC SYSTEM

BACKGROUND OF THE INVENTION

This is a continuation-in-part application of copending Serial No. 07/354,267 entitled SIMPLIFIED DATA INPUT SYSTEM FOR DYNAMIC BALANCING MACHINE AND WHEEL DIAGNOSTIC SYSTEM filed May 19, 1989 which was a Continuation-in-Part of Serial No. 250,360 entitled Simplified Data Input System For Dynamic Balancing Machine filed September 28, 1988.

This invention pertains to balancing machines and more particularly to a dynamic balancing machine having means for the automatic entry of balancing parameters, the automatic detection of tire run out or force variation and the detection of wheel run out, which is particularly useful in supplementing the dynamic balancing of vehicle wheels.

Three sources of wheel vibration include force variation, run out and imbalance of the wheel/tire assembly. Heretofore, machines have addressed each of these sources as a separate problem thereby requiring three separate machines and three separate operations.

Heretofore, with respect to dynamic balancing machines, at least three measurements have had to be taken manually, and then each measurement manually entered into the computing section of the dynamic balancing machine by manipulation of an associated dial or key. This arrangement, accordingly, provides six stages where human error can occur.

When balancing a vehicle wheel, the three typical values which have had to be entered have been wheel diameter, D, wheel width, b (i.e. spacing between the rims of the wheel), and the "a dimension" (i.e. the displacement between the plane of the rim confronting the side of the balancing machine and a known position on the machine).

By using the force variation/run-out portion of the apparatus herein together with the computer section of the balancer and a video read-out or a printer the status of all wheels on a vehicle can be detected as well as the condition of each wheel rim. Thus, a video display provides all of the above information for (a) the tire (b) the wheel, and (c) the best combination of the wheel and tire rotationally disposed with respect to each other.

As disclosed herein, means are provided for automatically entering these values in response to carrying out a simple maneuver by the operator of the machine. Accordingly, by reducing the number of operations, human error and time become substantially reduced.

Further, the information thus entered is employed to calculate the parameters, "a" dimension, b, and D.

In general, in a dynamic balancing machine employing an elongate drive shaft for carrying a wheel on one

end to be rotated therewith and having bearing means containing and supporting the shaft for rotation, an automatic data input device, as disclosed herein, enters measured information for use in calculating the value of balancing parameters. This device comprises means carried by the machine to be movable to advance and retreat into and out of contact with a portion of the wheel lying in the plane of each of the two rims of the wheel to provide means for entering signals representative of the width of the wheel being balanced. In addition, the dynamic balancing machine as disclosed herein employs means carried by the machine to be movable into and out of contact with a portion of the adjacent wheel rim for entering information which can be employed to measure the displacement of the plane of the adjacent wheel rim from a predetermined portion of the machine, and in this manner to provide the "a dimension".

In addition, the automatic data input device includes means carried at the free end of the movable shaft means which is positionable to generate information in the form of an electric signal representative of information which can be converted to the diameter of the wheel to be balanced. The present invention, as characterized by means for matching high and low runout locations between the rim and the tire and having means for displaying the angular displacement required between rim and tire to provide a "match" therebetween, has been further characterized by provision of means for separating the tire from the rim or wheel, hereafter referred to as a "bead breaker".

Accordingly, applicant provides a single machine which (a) balances a wheel/tire assembly, (b) detects the runout of both the wheel and tire, (c) provides

the information indicative of the amount of rotational adjustment of tire to wheel (or rim) to achieve a "match" therebetween (to accomplish a maximum amount of "roundness" to the wheel/tire assembly), and (d) carries on the same frame a "bead breaker" for readily permitting the operator to rotate the tire with respect to the wheel to achieve the "match" of (c) above.

OBJECTS OF THE INVENTION

In general it is an object of the present invention to provide an improved data input assembly to be associated with a dynamic balancing machine.

It is another object of the invention to provide a data input assembly for automatically entering a plurality of parameter values in response to carrying out a simple maneuver on the part of the operator.

It is yet a further object of the invention to provide an automatic data input device in a dynamic balancing machine in which the spacing between the rims of a wheel can be simply derived from information automatically entered.

It is yet an additional object of the invention to provide an automatic data input device in a dynamic balancing machine in which the "a dimension" and the diameter of the wheel can be readily calculated from the information detected by the machine.

It is yet an additional object of the invention to provide a separate run out force variation device which is engaged automatically during the balancing cycle.

It is yet an additional object of the invention to provide for the automatic run out/force variation measuring device to act as a braking means on the wheel.

It is yet an additional object of the invention to provide a dynamic balancing machine which not only provides for detection of dynamic imbalance but also serves to detect run out of the wheel and the wheel/tire assembly, as well as the degree and location of force variation.

It is yet another object of the invention to provide a means of matching high spots due to run out or force variation of the tire with low spots of the rim run out and of finding the angular displacement between these two points.

It is yet another object of the invention to provide means carried on the main frame of the balancer for purposes of separating the bead of a tire from an associated wheel so as to permit the tire to be rotationally positioned on the wheel.

The foregoing and other objects of the invention will become more readily evident when considered in conjunction with the following detailed description of preferred embodiments when taken together with the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a diagrammatic perspective view of a wheel balancing machine according to the invention;

Figure 2 shows an enlarged perspective view of an automatic data input device according to the inven-

tion as used with the dynamic balancer shown in Figure 1 and according to the invention;

Figure 3 shows a data input system according to the invention;

Figure 4 shows a plan view identifying the three parameters of wheel diameter, "a dimension", and wheel thickness;

Figure 5 shows a diagram illustrative of how the sensed information can be converted to the parameters x, y, z of a point in space;

Figure 6 shows a side elevation diagrammatic view of means for detecting force variation or run out in a tire;

FIGURE 7 shows an enlarged diagrammatic view of a video readout of wheel diagnostics;

FIGURE 8 shows a flow chart pertaining to the functioning of the system;

FIGURE 9 shows a sample print out form, and

FIGURE 10 shows a diagrammatic perspective view of an automatic data input machine carrying a bead breaker assembly mounted to one side thereof within reach of the operator.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in Figure 1, a dynamic wheel balancing machine 10 includes a frame or housing 11 having a control panel 12 on an angular front portion of the machine. The wheel 13 and tire 14 carried on the end

of a rotatable axis 16 is driven in a rotational fashion by means of a motor 17.

A computer section 18 serves to calculate the values of input parameters as measured by the input assembly 19 (shown best in Figure 2).

Accordingly, the automatic data input system disclosed herein serves to measure input information to be supplied to computer means 18 for use in calculating balancing parameters or other data. The information input system comprises an elongate radius arm 21 supported by a rigid arm 20 secured to extend laterally away from a side plane of balancer 10. Radius arm 21 serves to pivot about a substantially vertical first axis 22 for operating a first angle sensing means such as potentiometer 23 disposed on axis 22 to sense the degree of pivoting movement of radius arm 21 in a substantially horizontal plane. Thus, the wiper (not shown) within potentiometer 23 is movable by rotation of radius arm 21 about axis 22.

An elongate shaft 24 carried in a generally upright position by radius arm 21 has been mounted to pivot about a substantially horizontal second axis 26 disposed transversely to first axis 22 and spaced therefrom. The second potentiometer 27 serves to sense the degree of pivoting movement of shaft 24 in a substantially vertical plane. Shaft 24 includes a predetermined length 28, the upper end of said length or shaft serving to define a reference point 29 in space. Elongate contact arms 31, 32 extend laterally to opposite sides of reference point 29. Each arm carries a sensor means 33 in the form of a microswitch on the ends of arms 31, 32 for entry of information into computer 18, the information being

derived from the status of angle sensing means, such as potentiometers 23, 27. In addition, the upper end of shaft 24 carries an offset grip 34, carrying an information entry control button 35. As thus arranged the value of angles sensed by potentiometers 23, 27 can be sensed and fed to computer 18 either by providing a contact responsive sensor 33 whereupon merely making contact causes the information to be entered; or sensors 33 can be replaced by surface following elements, such as by ball bearings and urged against the side wall of tire 14 whereupon depressing button 35 transmits the value measured by each potentiometer 23, 27.

As shown in Figure 5, the information sensed by input assembly 19 is readily converted to the parameters x, y, z defining a point in space as now to be described. A known length, T, along radius arm 21, and along shaft, S, are both moved as above described through angles sensed by angle sensor means, such as potentiometers 23, 27 to define angles θ, ϕ, respectively.

Thus, the hypotenuse in the X, Y plane is shown as defined by the combined value of $(T + S \sin \phi)$;

the value of x then is measured by $(t + s \sin \phi) \sin \theta$,

the value of y is $(T + S \sin \phi) \cos \theta$; and the value of z is simply $(S \cos \phi)$.

As thus calculated for three parameters, x, y and z, are readily measured to define a point in space. Then by entering the parameters for two points in space computer 18 can be suitably programmed to readily compute an appropriate dimension, such as the

"a dimension", wheel rim width, b, or wheel diameter, D. It is further to be understood that the radius struck by movement of shaft 24 is defined by the displacement 28 which is a known value. Further, the radius struck by arm 21 is a known value. The angle of movement of both shaft 24 and arm 21 is defined by the potentiometers 23, 27. From the foregoing it will be readily evident that there has been provided an improved data input system as shown best in Figure 3.

It is also possible to determine dimensions a, b, and D (Fig. 4) by use of a look-up table in place of the direct calculations as noted above.

Accordingly, system 30 in Figure 3 includes a power supply 41 which supplies power to switches 42 suitable for controlling computer 18. The output from each of the two potentiometers 23, 27 is fed via leads 43, 44 to an analog to digital converter means 46 of known construction via switch means 35a, 36 controlled by the information entry control button 35. The output from analog to digital converter 46 is supplied to computer 18 via lead 47. Accordingly, computer 18 serves to determine the parameter a for points in space in terms of x, y and z, or in terms of polar coordinates if desired, a look-up table, or the like. Having determined the parameters x, y, and z, computer 18 is suitably programmed to provide desired comparisons between two points in space with respect to each of the three wheel balancing parameters a, b, D (Fig. 4).

In operation, sensor follower contact 33 (or microswitch) of arm 31 is moved laterally with shaft 24 together with movement of radius arm 21 into engagement with the peripheral lip of rim 15. With contact

33 of arm 31, disposed in engagement with the peripheral lip of rim 15, information pertaining to the angle detected by potentiometers 23 and 27 will be entered into computer 18, either by operating the information entry control button 35 or by having position sensor contacts 33 engage rim 15 and by so contacting the rim the sensor contact 33 becomes activated so as to transmit information from a potentiometer. Then shaft 24 is drawn away from the plane of the front portion of housing 11 and moved sufficiently to be clear of tire 14. Contact 33 associated with arm 32 is moved laterally into engagement with the outer rim 15′ of the wheel/tire assembly. The new readings for potentiometers 23 and 27 will be entered into computer 18 and a second point in space will be defined as above described. This second point in space will be on the opposite side of wheel 13 from the first point in space.

Entry of the foregoing information provides data for computer 18 to calculate the wheel width, b, the "a dimension" parameter as well as the wheel diameter, D, parameter. In short, by taking two readings at two positions of shaft 24 all information for the three parameters required to balance the wheel will be capable of being computed for use in solving and comparing various points in space.

From the foregoing it will be readily evident that there has been provided an improved information entry system which serves to minimize the degree of human involvement. Accordingly, human errors will be minimized, and time will be saved.

According to a still further embodiment of the invention, a roller or other means carried on a pivoted arm is activated automatically during the

balance cycle (or manually at any time) to measure tire and wheel run out or force variation.

Thus, it is known that the material of tires is not entirely uniform and typically contains certain hard spots in the tire. These hard spots provide for vibration in the ride which cannot necessarily be eliminated simply by balancing the wheel. Accordingly, location of such hard spots is considered important and the embodiment disclosed herein provides for sensing of such hard spots.

This is referred to as force variation. As disclosed in Figure 6 a roller 100 carried by a lever arm 101 having a pinion 105 carried at an end of arm 101, pivots in bearings 102.

It is also known that run out of tire and or rim will also cause vibration even when balanced.

Activating cylinder 103 via valve 114 controlled by computer 18 serves to urge a piston (not shown) to move roller 100 so as to contact a spinning tire 14 of various sizes. In this manner the roller is pressed firmly against the tire and suitable force sensor means (or angle sensing means) 104 detects radial run out or force variation information and transmits these readings to computer 18 to be stored and shown on display 36.

Figure 7 shows a preferred display 117 which includes a graphical representation of a balancer and wheel, 158, indicative of out of balance readings and points 161, analog force variation/run out graph 118 with associated digital reading 159 and indication of status as being good or bad, etc., plus what to do next, i.e., press rim button at 121, for example.

Thus, a graphical display of wheel and balance information including weight and position plus runout information appears on the screen. In addition, graphical forms of the above information are also provided. Also, it is preferred to show the runout in horizontal bar graph format plus digital readings of same and indicating whether the wheel, tire, or both are in or out of specification. Having all this information on one screen rather plainly and clearly makes it relatively easy for an operator to make appropriate corrections.

Whenever the wheel/tire assembly of graph 118, Figure 7, is not within specification and accordingly noted to be "not good" an additional message is flashed on the screen in the region of the comment portion thereof, 121, to "press rim".

When rim button 121 is pressed as directed above, a display 113 provides a three screen graphical display in the sense that each of the traces 118, 119, 120, identify a given "screen" and wherein each of these three screens is associated with actual digital information showing wheel outside diameter, force variation/runout, plus rim runout in two axes. The third "screen" 120 shows the matched results of the computer's combining traces 118 and 119 in an optimum manner and this screen 120 also includes diagnostics and summary of in or out of specification indications and instructions to the operator as to what to do next, or what possible problems are causing the indicated result.

Figure 7A shows a preferred display 117 which includes a plurality of three graphs, 118, 119, 120, associated with digital information indicative of the

number of inches which a given wheel or tire is out of round and each graph is accompanied by words stating whether the graph is good, bad, or otherwise. Finally, at the bottom of display 117 a comment is made which is generated by the computer indicating the status of the rim and tire, and possible diagnosis.

Graph 118 in Figure 7 shows run out of tire and rim assembly;

Graph 119 shows run out of rim only; and

Graph 120 shows best possible match available, with position of valve stem 137 indicated so that the best match can be achieved.

A flowchart as shown in Figure 8 represents the general operation of computer 18 in diagnosing and displaying wheel run out data and appropriate causes. Accordingly, the system is initiated by pressing a start button 122, a memory unit 123 stores the specifications which are required for a given wheel/tire combination as well as for the wheel and tire per se. Accordingly, the computer can compare whether or not the rotating wheel and tire assembly provides the appropriate force variation runout as being "good" as it stands (or as noted in the drawing "good as is"). If this is true then the information detected is transferred directly to the memory 124 and the balance of the wheel is displayed by the unit 126.

In addition, by pressing the start button the full screen, Figure 7, is displayed and shows (Figure 7) that the wheel/tire combination is "bad". This screen also provides an instruction to the operator

to push the rim button so as to determine whether or not the problem lies with the rim or otherwise. The result of this action can provide a display that the rim is "good", as noted in unit 127. If, however, axial runout as shown at the left hand end of screen 119 is out of tolerance, the wheel is "bad" as distinguished from the tire and is so noted above the rim graph 119 or the computer automatically provides this. The operator is then instructed to attempt to match the first and second traces 118, 119 to see if some satisfactory matching of these two units can be made. This is shown in the box noted as 128 and obviously provides a result that even if match can be made, this leads to the conclusion that the bad axial runout indicates rim damage as shown in box 129.

In addition to the above, a third output via lead 131 activates the portion of the display indicating that the rim is "bad". Noting that the rim is bad, a match is attempted with the tire shown in trace 118 and this can provide either that the match can be made or it cannot be made. Box 136 indicates that it can be "good". In the present instance, the box 132 indicates that the match is "bad" suggests that the match cannot be made. This is for one or the other of two reasons. If "bad", the operator is instructed to detect the status of the tire seating per se for either the tire is "good" but the bead seating is "bad", or the tire is "bad" if the bead seating is "good" for 134. If the tire is "good", then he is instructed to check the mounting or the wheel center, as noted in box 133.

Finally, in box 136 after a "good" match has been shown possible by 136 or graph 120, then the operator moves the tire, thereby moving valve stem 137 of Figure 7 to center line 138. When this is aligned,

the operator marks tire at 12 o'clock and subsequently rotates tire and mark with respect to the rim (or wheel) until it is opposite the actual valve stem on the rim, thereby causing the wheel tire assembly to be best matched, i.e., having the tire's high spot aligned with the rim low spot as indicated by graph 120.

As noted above the invention not only serves to detect the dynamic imbalance in a wheel/tire assembly but also serves to detect runout of the wheel (rim) and loaded runout of the wheel/tire assembly, as a whole. The machine also detects the degree and location of force variation. The invention further provides means for matching high spots caused by loaded runout or force variation with low spots or runout of the rim, as well as detecting the angular displacement between these two locations.

Accordingly, when there is shown to be a need for rotational movement of the tire about its wheel to provide a preferred "match", the dynamic balancer operator will usually dispose the wheel/tire assembly on a tire demounting machine. As shown herein, however, I provide a bead breaker 160 as best shown in Figure 10 to be carried by the main frame 11 of balancer 10. Bead breaker 160 includes a mounting strap 162, folded at its ends 162a, 162b whereby strap 162 can be rigidly bolted to the frame of balancer 10.

Strap 162 carries a pneumatically driven cylinder 163 charged via line 164 from a pump (not shown) disposed within the enclosure of balancer 10. Means for charging cylinder 163 includes a foot operated switch 166. When operated, a piston (not shown) disposed within cylinder 163 moves to the left (as

viewed in Figure 10). The piston rod 167 rides in a bearing housing 168 and connects with a moveable pressure plate 169 referred to generally in the trade as "spoon" 169. Spoon 169 carries a positioning rod 170 for controlling the orientation of spoon 169 whereby the edge of rim 13 will not be pinched together when piston rod 167 is urged outwardly thereagainst. The other side of tire 14 engages a stationary spoon 171 whereby as piston rod 167 is urged outwardly of cylinder 163 (with tire 14 deflated) the sidewalls of tire 14 disposed between spoons 169, 171 collapse away from rim 13.

Reversing foot switch 166 serves to discharge air pressure within cylinder 163 to permit an internal spring to return piston rod 167 to its retracted position.

Generally Figure 8 shows a list of possible errors and a corresponding list of probable causes or actions necessary for which the computer is programmed.

As shown in Figure 9, a typical type of readout sheet is provided for each of five tires. Accordingly, the system as described indicates immediately and automatically whether the wheel/tire combination or wheel or tire is within spec or not. In short, the results of the diagnostic procedure outlined above where the outside diameter of the wheel/tire combination is bad, the wheel can be good therefore the display is shown that the tire is bad and the wheel is good. Another option is where the outside diameter of the combination is bad and the rim is the same runout as the wheel/tire combination, the display will show that the tire is good and that the wheel runout is bad. Where the outside diameter of

the combination is good, the display will indicate that everything is good. Or, if the outside diameter runout is bad the operator will be instructed to measure the rim OD to see that it is satisfactory. Should the rim have axial runout, this is shown as bad because the rim is buckled. Hence, the machine diagnoses and displays the rim being buckled and needing replacement. Or, where the outside diameter of the assembly is bad and the rim is measured and it is found to be bad but not buckled, the conclusion can be made that hence, either wheel center could be bad or the wheel good and the mounting is bad.

Thus, (Figure 9), an automatic printout of the balance data plus force variation/runout data in each individual tire of a set of five tires is provided in a summary format including diagnostics, i.e., what to do with each tire. Each of the tires is marked prior to or during test by the numbers A1 through A5 and numbers A1 through A5 are injected into the memory to be included in the printout summary.

The computer is programmed to keep track of and memorize each wheel being tested so that a summary can be printed and wheels rated.

A button or buttons are provided by which an operator indicates the number of a wheel being balanced, i.e., A1 being wheel 1 of set A, first set to be done. B2 being the second wheel of second set, etc. In this way, each set of wheels per vehicle and each wheel in the set can be accounted for.

Whenever a new set of wheels is tested by automatic measuring or manual entry is used to input size of wheel and position on balance shaft, this input is automatically used to move from A to B to C, etc.

during use of the machine. Wheel A2 from set A can be retested even after set C is done by entry of A2 into the computer by the operator. If this is done, A2 is obviously a retest and this data is entered into the memory in place of the previous A2 data.

When the operator requires a print-out, a print button is pressed to automatically print out data and information for a set of wheels, be it one or 5, corresponding to the data of the wheels entered into the computer prior to the print button being pushed. (i.e., if the wheel just diagnosed is D4 and this D4 has been either automatically or manually stored, then when the print button is pushed the wheel D1, D2, D3 and D4 will be printed and summarized.)

The computer can also be programmed to automatically put out this data by each input of new wheel data causing put out of the previous wheel set.

The printout summary serves to indicate whether the tires are good or bad, whether the front or back wheels are rejected, and if so, why. Force variation/runout gives indication of good or bad vehicle specifications to be entered into the memory. And good and bad can be indicated according to those specifications. If indication of bad or suspect, the operator may then manually input two axis rim runout data via the input wand noted above. The machine will then automatically diagnose and display the best match between the tire and rim thereby indicating:

a) where the tire is bad;
b) where the rim is bad;
c) where the wheel is bad (buckled);
d) or whether there is a mounting error;
e) or whether the assembly is good.

(a) If the outside diameter of the tire and wheel assembly is indicated as bad, the machine will automatically request the operator to measure the rim, and hence, the computer will automatically compute the result, which is displayed together with the diagnosis per the above.

(b) The diagnostic program discloses information such that if the outside diameter of the assembly is bad and the rim is good, then the tire is bad. If the outside diameter of the tire is bad and the rim is bad to the same degree of runout in both amplitude and phase, then the tire is good and the rim is bad.

(c) If the outside diameter is bad and the rim measures indicate excessive axial runout, then the wheel must be buckled, and damaged.

(d) If the outside diameter is bad and the rim is similarly bad as per (b) above, then either the wheel center is bad or there is a mounting error.

(e) If the outside diameter is bad and the rim is bad but 180° out of phase, then the matching data can be calculated and displayed with an indication of how good the resulting matching will be.

The printout shown in Figure 9 further includes both digital and analog information recorded thereon. Note for example that under tire A1, under force variation runout, a curve is recorded. Following this a digital number appears indicating that the tire A1 is within 3/10ths of a millimeter. The second millimeter which was generated by matching the best of both the wheel and tire for tire A1 is also recorded to the right thereof and if that and another digital number appears indicating that the mount of

disparity. In the right hand column, the analysis provided for that tire indicates that it is good.

The same routine is used for all the remaining tires.

With respect to a balancing chart shown at the top of Figure 9 the columns indicated as "in" and "out" refer to the addition of weights on the inside and outside of the wheel. Thus, in tire A1 if 60 grams of weight are added inside the wheel and 35 grams to the outside, a total amount of weight added will be 95 grams.

From the foregoing it will be readily evident that there has been provided a singularly improved wheel analyzing device and means for generating diagnostics for each.

The run out of rim is obtained as mentioned by use of the wand. If the wand touches the inside then this data is used after inputting rim data via the wand. The rim button is pressed a second time, then the other side of the rim is measured and the software automatically averages the inside and outside of the rim and displays an averaged value of run out.

Service wheels of different size and performance can have different values of run out and be good. The computer is programmed with this information.

The wheel size is determined by both input data of the wheel width and diameter, either manually or automatically, by the auto measuring device of Figure 2A and also by the diameter of the tire which is obtained either by the above-mentioned automatic measuring device, or by automatic force variation/run out arm 101 and potentiometer 102. This information

is used to calculate the wheel size and is put into the memory. The software is able to compare wheel size with whether the run out is good or bad and display such information.

Information of radial tire run out, or force variation, or radial rim run out can be stored by computer 18 and the tire and wheel matched whereby the minimum amount of run out of the wheel and tire can be accomplished. Return spring 116 anchored between the frame 11 and arm 101 serves to retract roller 100 in response to venting cylinder 103.

In a preferred embodiment, roller 100 automatically engages and disengages during the balance cycle to measure tire run out or force variation.

This run out or force variation will then be displayed along with balance information.

If this run out or force variation is excessive, then the operator can manually measure wheel rim run out. If the maximum tire run out and minimum wheel run out do not coincide, which would be unusual, then the angular displacement of the maximum tire run out or force variation and minimum wheel rim run out can be calculated by the computer and displayed.

In this way the tire can be rotated on the wheel by the operator to give the optimum possible wheel/tire assembly with regard to maximum "roundness" of the overall wheel/tire assembly, or minimum force variation of tire and wheel assembly.

A preferred embodiment entails automatic run out after balance readings are taken, but before the braking cycle commences. The amount and angular

displacement of the maximum run out or force variation by the roller is stored in computer 18 and displayed on display 36.

The operator then presses a rim run out button 48 (Figure 1) while holding the end of follower 33 of contact arm 31 against rim 15 adjacent the valve stem 49 (or some other reference point). Computer 18 then calculates and displays the angle necessary to align the maximum force variation or main run out point to coincide with the minimum run out on the rim with reference to the valve position.

By pressing the "match" button 50 this angle becomes displayed.

The present machine enables the operator to measure run out of the tire or rim manually or automatically in order to determine if excessive amounts of run out are present in either the tire or the wheel.

Arm 31 is placed in contact with tire 14. Then, as the wheel/tire assembly is rotated, the actual run out will be derived by changes in the angle θ and shown on display 36. Likewise by holding arm 31 to dispose the free end thereof to ride on the rim, rotate the wheel by hand, then run out of the rim in the X-Y plane can be shown on display 36 in response to movement of the wiper of potentiometer 23.

The preferred embodiment also has a braking means associated with roller 100, Figure 6, which is activated automatically after force variation and/or run out is taken so as to brake the tire/wheel assembly or assist in braking the tire/wheel assembly.

Thus, as shown in Figure 6, a pneumatic cylinder 111 carried on arm 101 moves a brake shoe 112 into and out of engagement with the surface of roller 100 for purposes of applying a drag to both roller 100 and tire assembly 14 in response to operation of solenoid valve 113 for driving the piston within cylinder 111 under control of computer 18. Brake shoe 112 is later returned to a retracted position by means of a return spring (not shown) within cylinder 111.

Thus, each wheel balancing parameter, a, b, and D derives from calculations of a combination of values taken from both sensors 23, 27.

Finally, the foregoing apparatus serves to determine the degree of relative rotation between tire and rim in order to provide an optimum "match" between tire and wheel rim. In order to release the tire from the wheel rim to achieve this match a bead breaker is carried from the frame of the balancer machine so as to minimize the amount of machinery required to be employed in a given service agency.

CLAIMS

1. In a dynamic wheel balancing machine of a type having computer means therein,

an input system for contacting the wheel for sensing and supplying information to said computer means for conversion to data associated with parameters of points in space employed in balancing a body,

said information serving to define suitable parameters capable of defining a first pair of points in space defining the diameter of a wheel to be balanced,

said information further serving to define suitable parameters capable of defining a second pair of points in space serving to define the spacing between the rims of a vehicle wheel to be balanced, and

a third pair of points in space serving to define the displacement between the plane of the rim confronting the side of the balancing machine and a predetermined known position on the machine.

2. In a dynamic wheel balancing machine of a type having computer means therein and an elongate drive shaft for carrying a wheel at one end thereof to be rotated therewith,

an automatic data input system for measuring input information to be supplied to said computer means for use in calculating balancing data,

said information input system comprising an elongate radius arm supported to pivot about a first axis,

a potentiometer disposed on said first axis to sense the degree of pivoting movement of said radius arm,

the wiper for said potentiometer being movable by rotation of said radius arm about said axis,

an elongate shaft carried by the radius arm,

said shaft being mounted to pivot about a second axis transverse to said first axis and spaced therefrom,

a second potentiometer disposed to sense the degree of pivoting movement of said shaft,

said shaft having a predetermined length,

the upper end of said shaft serving to define a reference point in space on said machine,

elongate contact arms extending laterally to opposite sides of said reference point,

means carried by the ends of said arms for entry of information into the computer,

said information being derived from the status of said potentiometers, and

means serving to transmit said status to the computer.

3. The invention according to claim 2 in which said axes of said potentiometers are disposed substantially mutually perpendicular to each other.

4. The invention according to claim 2 in which said shaft carries a control button at the upper end of said shaft whereby depressing said control button serves to activate the balancer controls.

5. In a dynamic wheel balancing machine of a type having computer means therein, an input system for contacting a tire carried by the wheel for detecting force variation in the tire, comprising

means for entering a reference point on the periphery of the tire into said computer means,

[means for urging a roller against the tread of a rotating tire,]

a pivot arm carrying a roller to ride on the tread of the tire,

means for sensing the degree of pivoting movement of the pivot arm force applied to said roller during rotation of said tire, and

means supplying the last named information to said computer means to permit said computer means to determine the location of the hardest part of the tread of said tire with respect to said reference point.

6. In a dynamic wheel balancing machine of a type having means for supporting a wheel/tire assembly for rotation with the end of a drive shaft, the improvement comprising means serving to detect force variation and radial run-out in a wheel/tire assembly, said means comprising an elongate lever arm pivotally supported intermediate the ends thereof, one end of said arm carrying a roller thereon extending transversely of the tread of the tire of the assembly, and means serving to urge said roller into engagement with said tread, means serving to detect the [force applied to said roller] <u>degree of pivoting movement of said pivot arm</u> throughout the circumference of the tire for detecting the locus of hard spots in the tread of the tire.

7. In a dynamic wheel balancing machine according to Claim 6 further comprising braking means serving to apply a drag to the wheel/tire assembly, said braking means being carried on said lever arm.

8. In a dynamic wheel balancer as in Claim 7 in which said braking means comprises a brake shoe disposed to move between retracted and advanced

positions to engage said roller while riding against said tire, and means for moving said shoe comprising a fluid operated piston in a cylinder carried on said arm.

9. A dynamic wheel balancer assembly comprising a rigid frame, means for supporting and rotating a vehicle wheel/tire assembly, and means for detecting the location and amount of counterbalancing weight to be added to the rim of the vehicle wheel assembly, means for detecting force variation in said wheel assembly and for detecting out of round portions of said rim, and means for designating where said tire should be rotationally located with respect to said out of round portions of said [wheel], rim to establish optimum "roundness"to said wheel/tire assembly, said rigid frame carrying a bead breaker for use in releasing said tire from said rim to readily permit said tire to be repositioned by rotating same on said rim to the position designated as the preferred position to establish said optimum roundness.

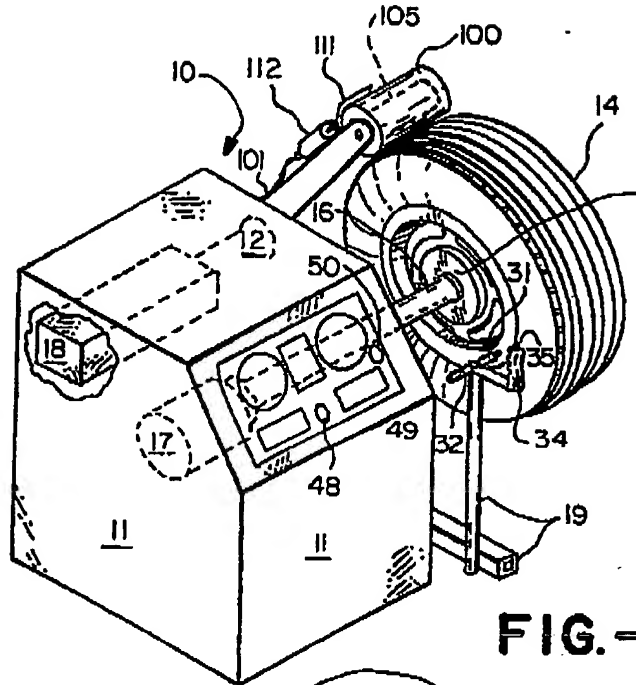

FIG.—1

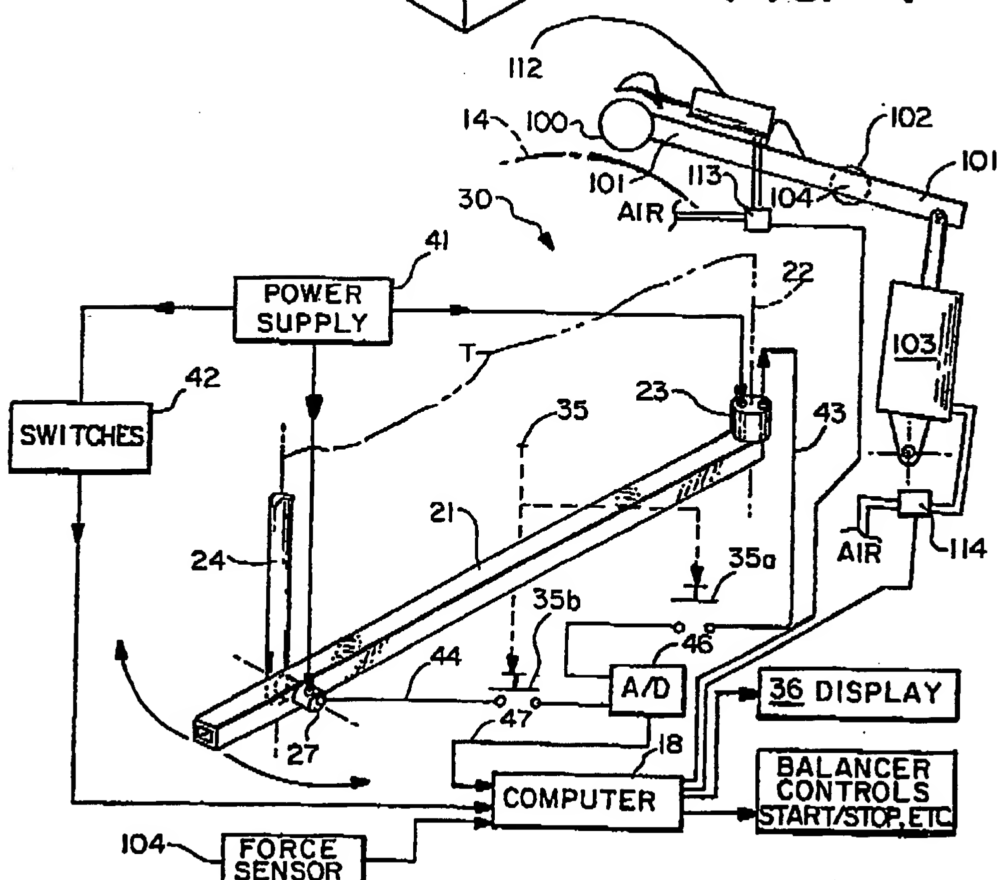
POWER SUPPLY
SWITCHES
AIR
AIR
A/D
36 DISPLAY
COMPUTER
BALANCER CONTROLS START/STOP, ETC
FORCE SENSOR

FIG. —3

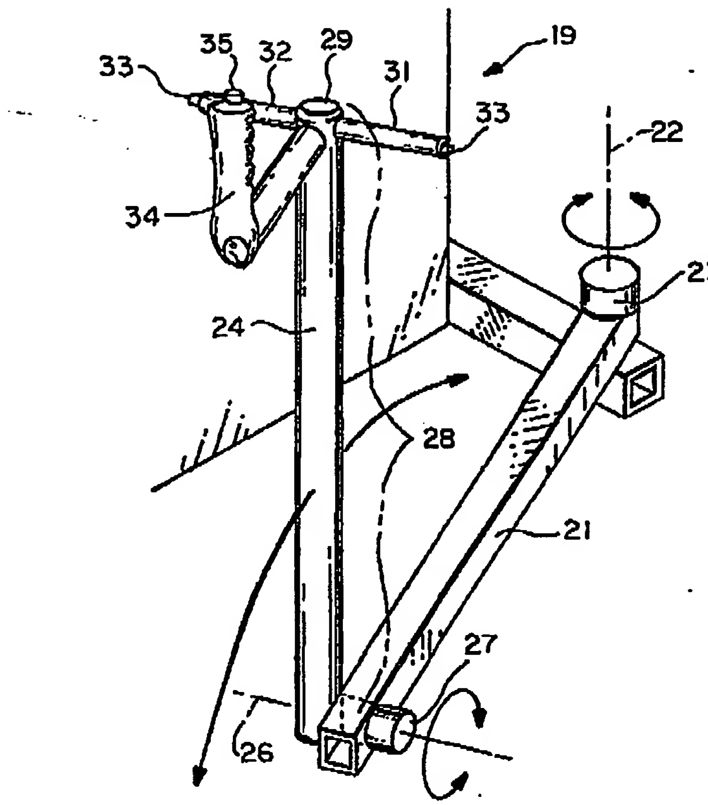

FIG.—2A

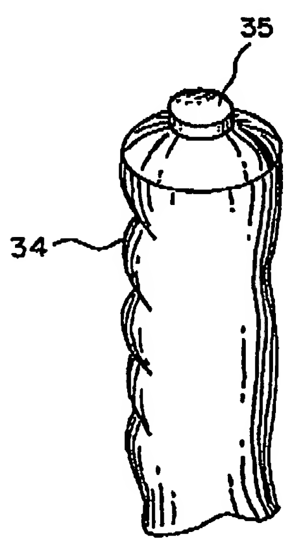

FIG.—2B

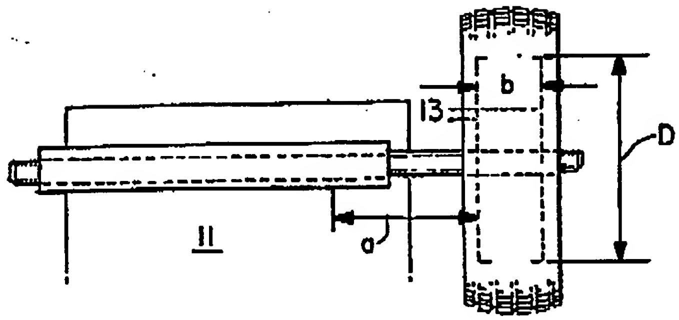

FIG. —4

LEGEND:
S = LENGTH OF SHAFT TO REF. POINT THEREON
T = LENGTH OF RADIUS ARM
θ = MEASURED ANGLE OF RADIUS ARM W/RESP. TO YZ PLANE
$\emptyset$ = MEASURED ANGLE OF SHAFT TO THE VERTICAL

HYPOTENUSE IN XY PLANE:

$T + S \sin \emptyset$

$y = (T + S \sin \emptyset) \cos \theta$

$x = (T + S \sin \emptyset) \sin \theta$

$z = S \cos \emptyset$

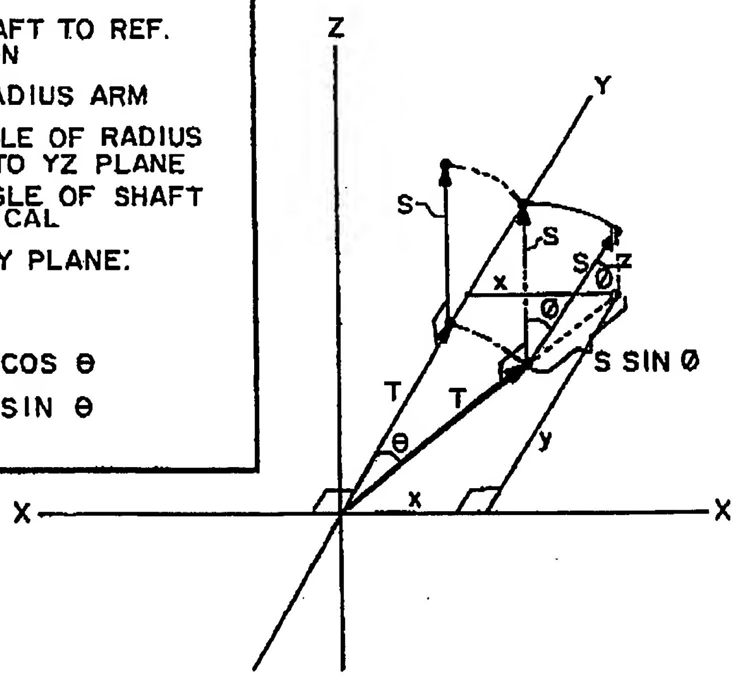

FIG. —5

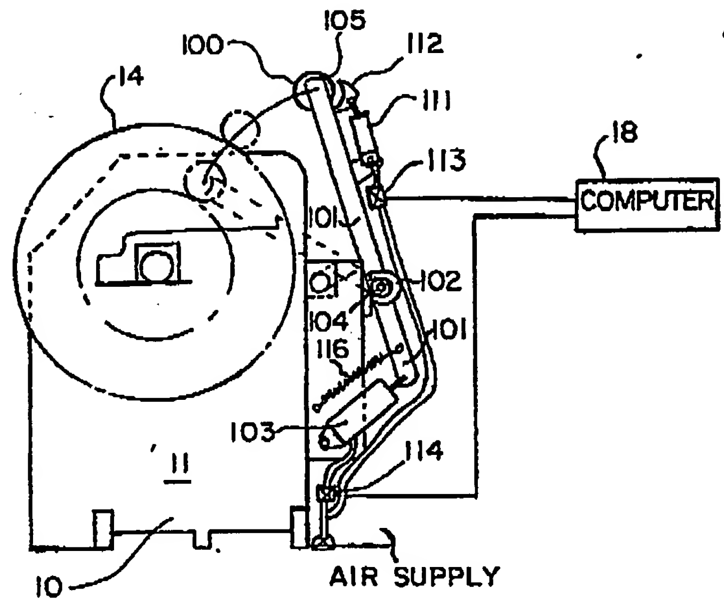
105
100
112
14
111
18
113
COMPUTER
101
102
104
101
116
103
114
11
10
AIR SUPPLY

FIG.—6

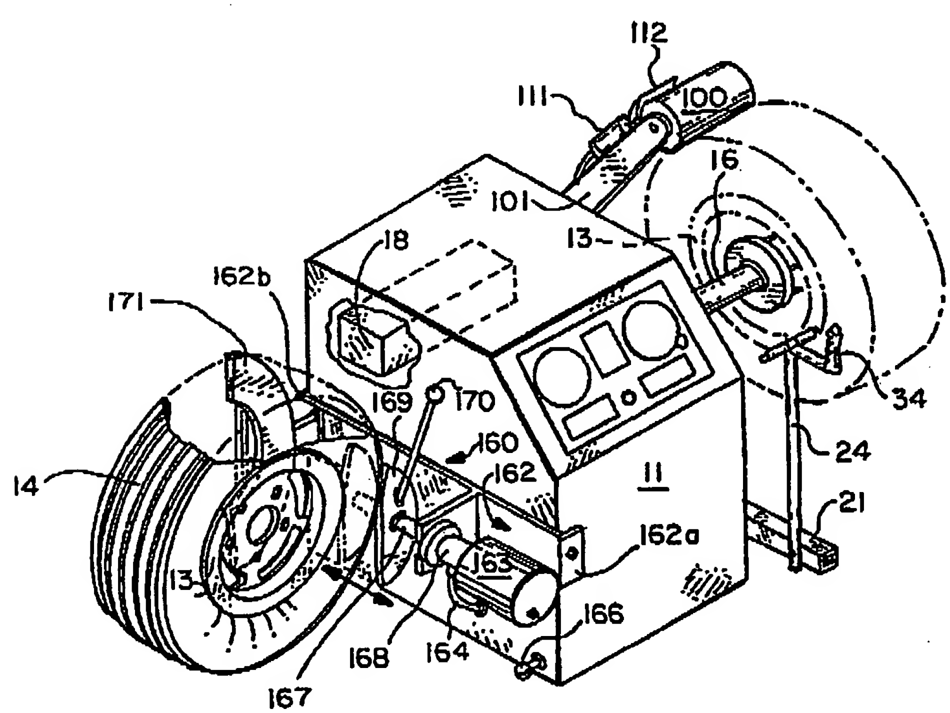
112
111
100
16
101
13
18
162b
171
170
169
160
34
162
24
14
11
21
162a
13
163
166
168
164
167

FIG.—10

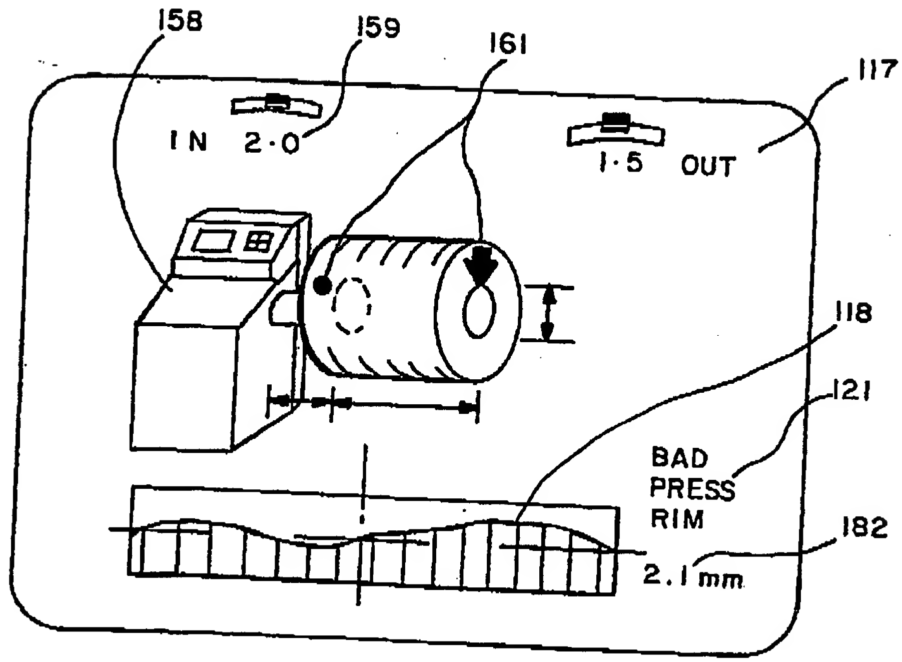
158
159
161
117
IN 2·0
1·5 OUT
118
121
BAD
PRESS
RIM
182
2.1mm

FIG. — 7

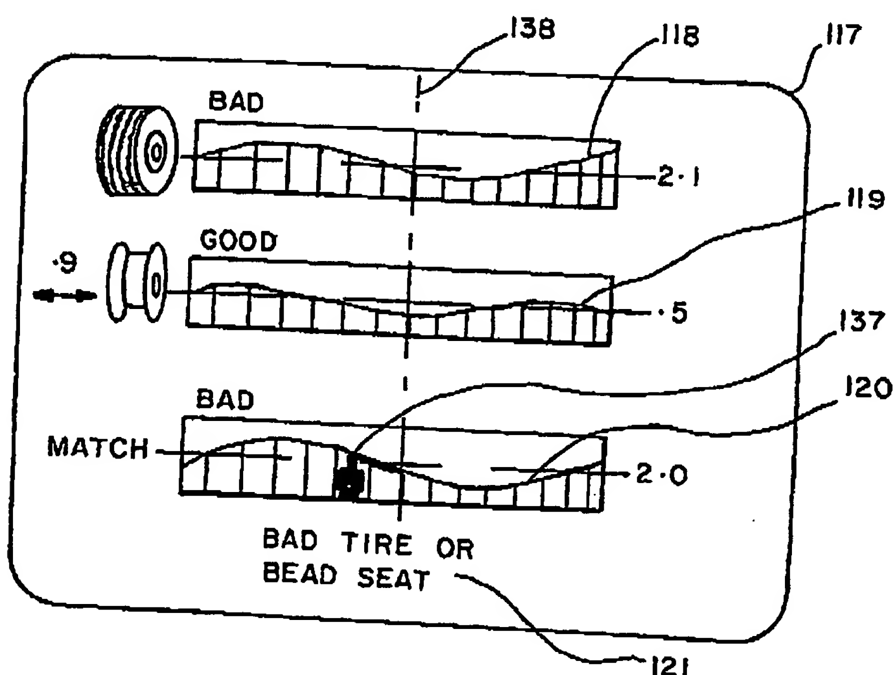
138
118
117
BAD
2·1
119
GOOD
·9
·5
137
120
BAD
MATCH
2·0
BAD TIRE OR
BEAD SEAT
121

FIG. —7A